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Submerged Burlap Strips Aided Rehabilitation of Disturbed Semiarid Sites in Colorado and New Mexico[1]

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Two planting sites with narrow submerged burlap strips showed 14 times less soil loss than control sites without burlap. Gullies and deep rills need to be reshaped to gentle swales before burlap is installed. Plant cover should become established before burlap disintegrates—about 5 years.

Keywords: Erosion control, bank stabilization, grassed waterways, flow control, mountain slopes.

The main objective in rehabilitating disturbed or deteriorated sites is to establish a vegetation cover that will not only alleviate erosion, but, by perpetuating itself, will also eliminate further maintenance costs.

Often, however, a plant cover cannot be achieved directly, and supplemental measures are needed. Some steps may be performed before planting or seeding, such as reshaping the topography; others may be applied simultaneously, such as fascine works, nylon netting, and brush and stone sills on hillslopes or road cuts. The submerged burlap strip, placed vertically into the soil and protruding somewhat above the ground surface, is a relatively new type of supplemental measure that has been effective in certain situations. This aid, closely followed by planting was used in two semiarid sites: one, on four manmade waterways in the Colorado Rocky Mountains; the other, on a road-cut slope in the Gila Mountains of New Mexico. The methods and results from these two tests are described in this Note.

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Design Criteria

The basic concept of burlap strip application for site stabilization is twofold:

1. A strip set vertically into the ground, acts as a mechanical reinforcement of the upper soil mantle. This strip cannot prevent soil creep or slides along its full length; however, it can prevent or reduce soil movement when only part of the strip length is endangered. Also, this method cannot stabilize slides that are seated deeper than strip depth.
2. The protruding portion of the burlap strip acts as a barrier to surface soil movement, thus increas-

ing surface stability. Because surface soil movement can hinder the establishment of plants with undeveloped root systems, surface stability is especially important where seeds or young plants are to be planted. Also, the several layers of burlap create a certain stiffness that prevents the surface-protruding portion of the strip from flattening. The protrusion retains its stiffness for about 2 years, and maintains a convex cross section that acts as a water spreader and miniature check dam for the surface flows (fig. 1). Flow concentrations and flow velocities are thus reduced. This change of flow regimen is especially important immediately following treatment when erosion hazards are greatest.

An additional consideration is how deep to insert the burlap strip. For soil mantle stabilization, the strip should be installed as deep as practical, time- and costwise. When slope angle, geologic structure, degree of solifluction, and other factors are compatible, a well-established grass cover effectively stabilizes the soil. Also, the main root system of most grasses and other herbaceous vegetation is located from a few inches to a foot below the ground surface (Berndt and Gibbons 1958). For our tests, the strips were inserted 10 inches deep, with a 1- to 3-inch protrusion. The rill depth on the test areas averaged less than 5 inches. Burlap strips would not be effective if the erosion channels exceeded 10 inches.

Study Sites

Alkali Creek Watershed

The first test area was on the Alkali Creek watershed in western Colorado, where four waterways were installed in 1963 to replace gullies. Altitude is approximately 8,000 feet, and annual precipitation averages 19.2 inches, 60 percent of which is snow.

The soils are derived from the Wasatch formation, of fluvial sedimentary origin, and consist of alternating layers of shale and sandstone. The alluvial soils where the waterways were imbedded have a clay content that approximates 60 percent; the remainder is primarily silt with a small percentage of sand. The montmorillonite clays give rise to high rates of expansion and contraction with soil-moisture changes that lead to excessive soil cracking.

The natural vegetation on the site of the waterways was oak brush and bunchgrass, with sagebrush on the bottomlands and depressions. Immediately following waterway construction, annual grasses and yellow sweetclover were planted to form a quick cover. The plan was to plant perennial grasses—smooth brome, intermediate wheatgrass, Kentucky bluegrass, and orchardgrass—the year after construction. The annual grasses, however, did not prevent rilling, and submerged burlap strips were installed in 1964 as additional surface protective measures.

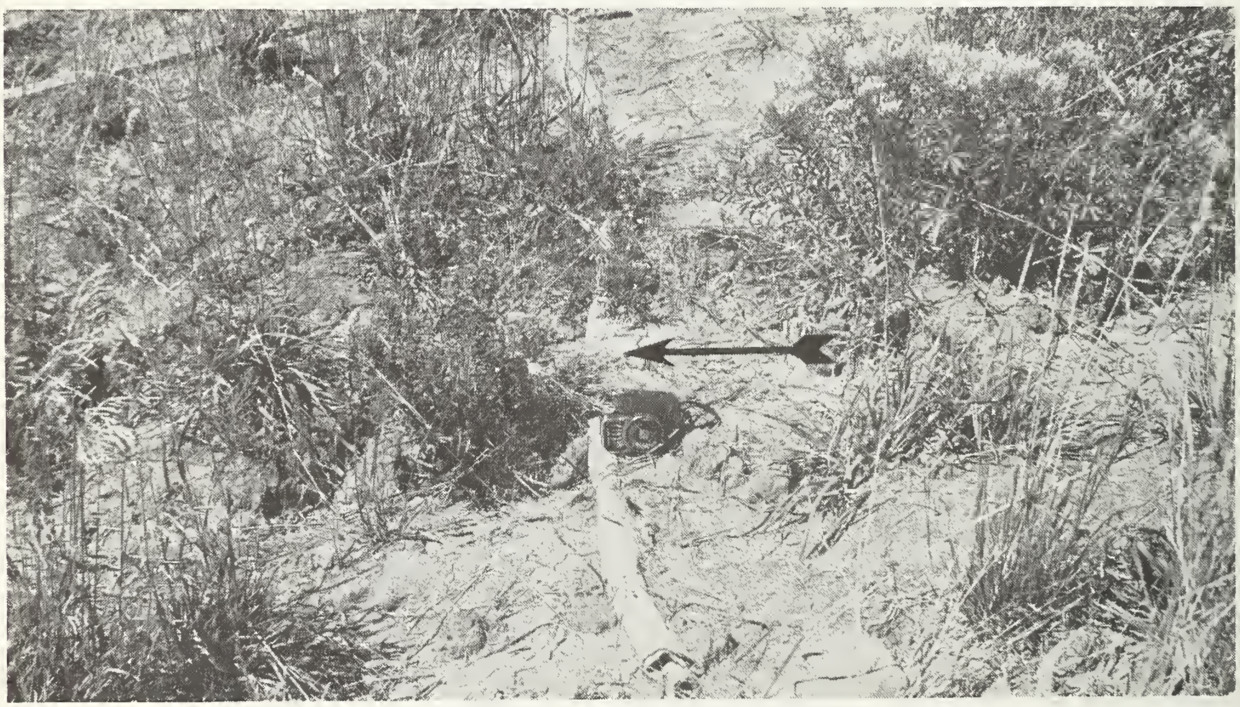

Figure 1.—Looking at a submerged burlap strip installed on waterway No. 6 on Alkali Creek watershed. Arrow indicates the direction of flow.

The cross sections of the newly installed waterways resemble topographic swales with gentle side slopes (1:8 to 1:12); flow depth is shallow and flow velocities much reduced. The average gradient of the longitudinal profile now ranges from 9 to 17 percent, and the average width of the waterway bottoms is 10 feet.

To install the burlap strips, we made 10-inch-deep furrows on the contour, with a moldboard plow. Burlap sheets, 10 feet by 10 feet, were folded into strips 12 inches wide and 10 layers thick. The strips were placed on the downhill side of the furrows, leaving 2 to 3 inches of burlap protruding above the ground surface. The furrows were then filled with the excavated soil, and the disturbed areas seeded to perennial grasses. Installation of 316 feet of burlap strips along with broadcast seeding took 8 hours for one man and a team of horses.

For the first 4 posttreatment years (1964-68), cattle were excluded from the watershed; then controlled grazing was reintroduced. Elk also used the watershed, especially in winter. Two herds of 26 animals each were counted repeatedly. Thus, from the beginning of the project, animal use was an integral part of the test.

From 1964 through 1969, the effectiveness of the submerged burlap strips was observed three times annually, which included snowmelt and runoff seasons, and the end of the summer. From 1969 through 1975, when the test ended, plots were observed sporadically.

Although high-intensity summer thunderstorms are common, the snowmelt runoffs that deliver concentrated flows for 4 to 6 weeks are a more severe test of our treatments. During snowmelt, saturation of the surface soil layer takes place, and the fine soils are erosion prone. While saturated, the soils disperse easily, and erosion hazard is especially pronounced on the slope gradients as high as 17 percent.

Gila Road Cut

Our second test with burlap strips began in July 1971 on a new road cut on the Gila National Forest in New Mexico, at about 8,500 feet elevation. The vegetation type is open ponderosa pine with some grass and brush understory. Nearby weather stations average 19.4 inches of annual precipitation; however, the fall seasons of 1971 and 1972 were unusually wet with high-intensity storms, and our erosion-control treatments were severely tested.

Soils on the cut slope were mainly reworked volcanic rock, tuff, and basalt. Like the Wasatch in Colorado, this formation had been fluvially deposited. The formation of duripan horizons indicates prolonged intervals of standstill, but the intervals were not long enough for more advanced soil development. On the cut slope, six horizons of duripan exist, separated by 3- to 6-foot layers of loose, sandy textured parent material that contains some gravel and cobbles of tuff and basalt. The platy duripans, ranging from a few to 9 inches thick, are relatively hard when newly exposed, but weather rapidly under the influence of precipitation and the atmosphere. Slope length on the area is about 50 feet, with average slope gradient of 50 percent.

Three plots, each 20 feet wide, were selected; a buffer zone separated the individual plots to avoid edge effects. The first plot was treated with burlap strips and western wheatgrass transplants. The second was planted to western wheatgrass without burlap strips, and the third remained untreated to serve as a control.

The burlap strips on the first plot were installed in hand-dug trenches 10 inches deep and as narrow as the tools permitted. Work started at the top of the bank and proceeded downslope. Excavated material was thrown above the trench. Burlap obtained in 4-foot wide rolls, was cut into sheets 20 feet long and folded into four-layer strips 1 foot wide. A burlap strip was placed against the vertical downhill wall of the trench so that about 2 inches of burlap protruded above the original slope surface (fig. 2). Then the excavation was filled and compacted by foot and hand tools. Western wheatgrass transplants were then planted above and adjacent to the strips (fig. 3).

Spacing between strips varied from 1.5 to 4 feet, and averaged 2 feet, to avoid duripans. The burlap installation obliterated rills. Not counting travel time, about 4 man-days were required to install 440 feet of burlap strip.

Sixteen transects, located on the slope gradient, were permanently marked by angle irons. The transects were established inside the plots, leaving buffer strips 3 to 5 feet wide. At each transect, a steel measuring tape was strung under tension between the angle irons. To obtain the same tension for later surveys, the distance between the iron supports was recorded with an accuracy of 0.01 foot. Elevations were measured by survey rod and engineer's level at points spaced 2 feet along the transects, for a total of 431 points. This survey was made immediately after treatment (July 1971), and repeated in October 1973.

When the new elevations were plotted on the original slope profiles, cross-sectional areas of erosion and deposition could be computed. The application of end area procedures yielded volumes, and subtracting deposition from erosion produced net erosion volumes.

The plots were revisited in November 1975; photographs taken in 1971 were compared with those of 1975 to aid in field evaluation.

Figure 2.—Placement of burlap strip into trench of road-cut slope on the Gila National Forest.

Figure 3.—The Gila burlap plot after planting. Straw mulch covers the transplants for protection against intense heating and excessive soil moisture depletion.

Results

Alkali Creek Watershed

On the Alkali Creek watershed, the submerged strips lasted and functioned for 5 to 6 years before they disintegrated and became ineffective. Remnants of the strips remain, however, 12 years after installation (fig. 4). It took 2 to 3 years for an effective perennial plant cover to become established. During the vulnerable time, the strips provided much needed stability to the waterways (fig. 5). Yet, on one reach of waterway 18, plants and burlap strips together did not stop the development of a major rill. The V-type cross section of the waterway in this reach, forced on the construction by a constriction of the valley bottom, did not allow adequate water spreading and flow concentrations took place. After 3 years, the burlap strips formed small check dams, which caused the flows to drop on unprotected ground surface below, where scour holes developed (fig. 6). Now a continuous channel up to 8 inches deep exists in this reach, and control by loose rock is planned.

Since time of installation, no maintenance on the strips was done, but the vegetation cover was enhanced by fertilization during the first 2 project years.

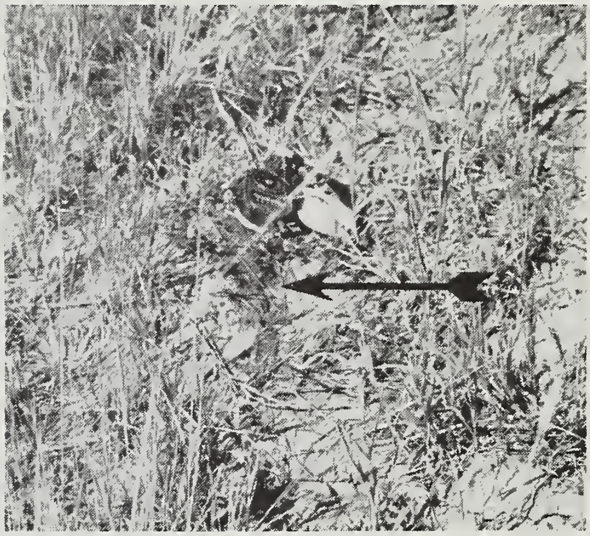

Figure 4.—Remnant of a burlap strip (arrow), 12 years after installation in Alkali Creek waterway No. 9.

Figure 5.—Upstream view of Alkali Creek waterway No. 6, 2 years after treatment.

Figure 6.—Looking upstream on middle reach of Alkali Creek waterway No. 18, where V-shaped waterway cross sections caused concentrations of flow.

Gila Road Cut

The October 1973 resurvey of the road-cut slope showed that, in spite of heavy soil disturbances on the plot with transplants and burlap, the differences in net erosion between it and the undisturbed control plot were nil for practical purposes (table 1). This result became obvious within a year after treatment (figs. 7, 8).

Although the gross erosion volume was somewhat larger on the burlap plot, it was offset by a larger volume of deposition (table 1). This finding must be evaluated in light of the fact that during treatment, the soil was disturbed more on the burlap than on the control plot where there was practically no disturbance.

In fall 1975, 2 years after the resurvey, the rills on the control plot had increased somewhat in depth and width, but were absent on the burlap plot. The strips toward the bottom of the slope could hardly be detected by eye, and toward the top they had flattened and formed one surface with the ground. The burlap was still fully intact in all strips. Our fear that water overfall at the strips on a 50-percent slope gradient might lead to undercutting and erosion had not materialized.

Also, although strip installation and planting had disturbed the soil surface much more than planting alone, the plants-only plot had 14 times more net erosion than the planted plot with burlap (table 1). The gully of the plants-only plot was still present 4 years after the survey and had increased.

Table 1.--Road-cut slope (treated July 1971), and influence of treatments on erosion and deposition as measured in October 1973

Treatment	Gross erosion	Depo-sition	Net-erosion	
			Volume	Depth
	Ft^3	*Ft*^{3}	*Ft*^{3}	*Ft*
No treatment (control)	23.82	18.90	4.92	0.0082
Transplants:				
With burlap	26.46	21.84	4.62	.0077
Without burlap	71.57	6.17	65.40	.1090

Figure 7.—The Gila control plot (no treatment) 1 year after study began. Note that continuous rills and gullies dissect the slope. The horizontal striations are duripan horizons.

Figure 8.—The road-cut burlap plot 1 year after treatment. Continuous rills and gullies did not develop. Stakes in foreground and on crest of slope are transect markers.

Discussion and Conclusions

Alkali Creek Watershed

From the waterway study in the Colorado Rocky Mountains we learned that submerged burlap strips can effectively stabilize surface soil if two specific requirements are met. First, an effective vegetation cover must become established within the limited life (5-6 years) of the strips. When the mechanical control no longer exists, rill or gully erosion may develop. Once continuous erosion channels are formed, erosion rates will increase manyfold and control requires a major effort. All this means that for successful application, the potential for vital plant growth must be high—naturally or fortified by man with fertilizer or other means.

Second, the morphology of the ground surface plays a major role for success or failure. Narrow depressions such as gullies or rills, should be reshaped to gentle swales before burlap strips can be used successfully. Otherwise, flow concentrations in depressions lead to larger depths of flow and render the submerged structures ineffective.

That one reach of our waterway failed cannot be attributed to the strips, since the morphology of this reach had an overriding influence. Where flow concentrations did not occur, that is, on the other three waterways, submerged burlap strips combined with an effective vegetation cover were successful.

Gila Road Cut

The road-cut slope study in the Gila Mountains indicated processes basic to a successful strip application. It demonstrated that the burlap strips can control surface disturbance caused during installation, that is, increased local surface soil movements are checked by the protruding part of the strips. Furthermore, the study showed that under the severe conditions of fresh road cut, strips were a beneficial addition to planting. After 2¼ years of treatment the burlap decreased net erosion from the slope by a factor of 14. One reason for this difference is that existing rills were obliterated (fig. 3) when the burlap strips were installed. This is not the case during planting alone, and the small grass seedlings are not effective in preventing additional rilling.

All strips were still intact 4¼ years after treatment, and in spite of a 50-percent slope gradient, undermining of the burlap by water overfalls did not take place. The flexibility of the burlap allowed the strips to conform with the ground surface.

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